SMOKE CONTROL

AS A PART OF BUILDING FIRE PROTECTION

Summary Minutes of Seminar on May 3, 1977

U.S. DEPARTMENT OF COMMERCE
National Fire Prevention and Control Administration
Washington, D.C. 20230

MEMBERSHIP

OF

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HIGHLIGHTS AND RECOMMENDATIONS OF THE NFPCA'S FEDERAL FACILITIES DESIGN STANDARDS TASK GROUP SEMINAR ON SMOKE CONTROL OF MAY 3, 1977

1. Highlights.

The following highlights are emphasized with no order of importance implied:

a. Test procedures have not been updated to reflect life safety hazards of modern man-made polymers, plastics, and synthetics.

b. Firefighting by building occupants without self-contained breathing apparatus may be deadly.

c. Exposure to minute quantities of hydrogen chloride (HCl) in air can cause disabling choking and burning sensation to eyes, nose, and throat. Polyvinylchloride releases approximately 58% of its weight as hydrogen chloride in a fire.

d. There are a number of factors, other than the heat of the fire, which allow delivery of dangerous quantities of smoke and toxic gases to locations remote from the fire regardless of design considerations, e.g. inversion or lapse, external temperature, wind direction, and building operations at the time of the fire.

e. When a building is heated, the difference between inside and outside temperature causes so-called "stack ffect." Due to pressure differences, air is drawn into any ventilating stack (stairways, elevator shafts, floor openings) in the lower part of the building. At about the mid-height of the building, there is a neutral plane (zone) where air flow is indeterminate. Above the neutral plane the flow of air is from the stacks to the floors. Gases from a fire below the neutral plane will follow the existing air flow paths and be delivered to floors above the neutral plane. Many variables affect the condition in a specific building. When a building is cooled below outside temperatures the affect is reversed.

f. Tests on non-pressurized buildings indicate the following:

   (1) Fire on a floor below the neutral plane can be spread into the corridor by airflow.

   (2) Smoke from floors beneath the neutral plane can be spread to upper floors by the air handling system.

   (3) Smoke on upper floors will be forced outside.

   (4) Weather can have a significant effect on pressures.

g. Some tests have indicated that pressurization of corridors to reasonable levels on floors above the neutral plane can contain a fire in its room of origin. The use of regular air handling systems is practical for most cases of smoke control and minimizes costs.

h. Pressurization is considered a sound method of smoke control. Further evaluation may lead to designs permitting the use of elevators by occupants for evacuation.

i. At present, there is a lack of complete understanding and knowledge in engineering smoke control systems. It is more of an art than a science and adoption of legislation without additional knowledge and experience can be counterproductive.

j. No one can actually state at this time for a given building precisely what amount of pressurization is required to achieve desired results. The only means of determining adequacy is by full-scale testing with a trace gas, such as SF_6.

k. Automatic smoke control mechanisms are subject to malfunction.

l. Wider use of smoke control systems is inhibited by potential liability considerations.

m. Research at the National Bureau of Standards and the Canadian Building and Research Council indicates that six air changes per hour is the maximum needed for smoke control; however, a minimum of three air changes may possibly be acceptable.

n. Smoke control requirements will virtually eliminate the need for fire dampers.

o. Based on local research, Atlanta, Georgia has required that all high-rise buildings built since 1973 include pressurization systems for smoke control.

p. In order to achieve reliability in smoke control systems, a design manual is essential.

2. Recommendations.

   a. Federal agencies should utilize research funds to assist in the formulation of a smoke control guide manual.

   b. Existing data about smoke control systems must be transformed into charts, graphs, tables, and formulae to include all parameters, such as wind, temperatures, building geometry, volume, and other special features as a "state-of-the-art" basic reference.

   c. In the design of new and rehabilitated buildings, smoke control should be seriously evaluated for feasibility for inclusion.

   d. Pre-fire planning for buildings containing smoke control systems should include contingency plans for the various stack-effects which may occur in the building at various times (e.g. various seasons of the year) and the need for self-contained breathing apparatus for building occupants.

Richard Klinker
Chairman
January 24, 1978

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MR. KLINKER: The Task Group on Federal Facilities Design Standards is open to all Federal agencies. The Task Group is set up to develop standards and guidelines for fire protection and fire prevention relating to buildings, structures and facilities. The areas of concern are occupancy and fire protection systems and equipment for assuring adequate consideration for life safety, continuity of operations and property protection.

The Task Group will assist in reviewing plans for new constructions, make independent studies of Federal buildings and property and consult with appropriate organizations. Thus the Task Group serves as a focal point for the various government agencies to learn what other agencies are doing.

MR. TAYLOR: The concept of the use of air for smoke and fire control is at a stage where sound design criteria must be available to architects, engineers, the fire profession, building code officials and others who have jurisdiction over the construction, maintenance and control of buildings.

Participants in the meeting include Dick Masters of Jaros, Baum & Bolles. Mr. Masters is chairman of the Subcommittee on Control of Fire and Smoke. Bill Schmidt of the Veterans Administration is the current chairman of the NFPA 90A Committee. Francis Fung represents the National Bureau of Standards Fire Technology and Record Section. He is chairman of the Handbook Subcommittee. Brooks Semple is Executive Director of the Smoke Control Association and secretary of the NFPA 90A Committee. John Fothergill is the last speaker.

Discussion followed on the National Disaster Survival show on network TV. It was felt that the show depicted several myths on life and fire safety which should be rectified. The National Safety Council will be asked to carry another TV special program to properly set the record straight.

The residence fire and high-rise procedures were seriously criticized.

Mr. Taylor then began a slide presentation on smoke and toxic fire gases. When a fire occurs the code mandates that the air system be turned off thus creating a "witches brew" of smoke and toxic fire gases from cellulosic products.

The chance of survival in many buildings is jeopardized by test procedures which have not caught up with the real life-safety hazards of many modern materials. Construction practices, too, often compound the problem of exit from and access to buildings and make smoke control and fire control difficult at best.

Building air systems and certain hazard control techniques can dramatically reduce both life and property risks.

The entire fire technology of the recent era was based on control of the "wood" fire. During this period so-called "fireproof" building construction came into being. Codes were aimed basically at protecting the integrity of the structure from fire. After numerous disasters, life-safety codes grew in importance and use.

Firefighting concentrated on putting out the fire. It was the age of the "smoke-eater" with smoke from cellulosic materials. Even though wood smoke is very high in the release of aldehydes and carbon monoxide, few considered toxic gases.

The concept of "fire load" was born to judge the degree of fire hazard of a building. This meant the fire endurance of a structure was based on the pounds of combustible materials in its construction and contents.

The ASTM E-119 test was developed and the E-119 typical fire curve is still used to determine the degree of fire resistance and performance of a system or material.

There is a new technology of man-made polymers, plastics and synthetics. These polymers are completely burned in less than five minutes, and the rate-of-smoke development is very great. Toxic hazards of the fire gases and flame spread can be so great that so-called "first aid" firefighting without self-contained breathing apparatus may be deadly.

The Ohio State Combustibility Test Method was reviewed. This test still uses wood as the material to evaluate the hazard of a fuel load.

The Federal Trade Commission has ruled that many of the test methods and standards adapted to cellular plastics are "not accurate indicators of the performance of such materials under actual fire conditions."

Further, the E-39, Hazards of Materials Committee of ASTM, is reviewing all Fire Hazard Test Methods and Standards for their relevancy under actual fire conditions.

PVC, for instance, releases approximately 58 percent of its weight as HCL or hydrogen chloride. Less than 200 parts per million of this gas combined with other gases when it decomposes can "arrest" an exposed person. The combined effect of these gases on an individual in a fire situation will depend on the amount of material involved, the rate at which gases are released, the size of space into which they are released, available oxygen, and the ability to evacuate the area.

Research is being done at the University of Pittsburgh which indicates that more potent sensory irritants than HCL may be involved. In a report presented at the International Symposium of Toxicity and Physiology of Combustion Products, it was revealed that HCL has been implicated as a major contributor to the overall toxicity exhibited by the thermal decomposition products of PCV.

The University of Pittsburgh work also indicates no difference in the degree of severity of the respiratory effects suffered from the thermal decomposition products of plasticized (PCV) as long as oxygen was above 14 percent, carbon dioxide below 10 percent and carbon monoxide less than 2000 ppm.

This data indicates that exposure to 0.10 to 0.22 milligrams per liter of air of HCL would be rapidly incapacitating with choking and burning sensation of the eyes, nose and throat. It also shows quite clearly that HCL alone is not the sole incapacitating agent.

Empirical gas concentration data and tests indicate that one pound of PVC, when burned, can release concentrations of HCL of 200 ppm into a corridor 10x10x50. Thus, a very small fire involving small surface areas of PVC could have large potential hazardous consequences to people moving in such a corridor.

Likewise, Fire Hazard Characteristic 3, "Smoke," carries many ramifications. Is it dark or clear, light or heavy, hot or cold, filling the entire area floor to ceiling or stratified?

Although gases and many early products of combustion are colorless, they are components of smoke. Most test standards, however, are written based on visible smoke, not invisible gases. The rate at which smoke is given off by a given piece of material is important and determines hazardousness.

The scope of the hazard has been changed with the high-rise construction and enormous growth in vast area structures. Through design and construction practices, firefighting is complicated in many ways.

Exterior factors which seriously hamper firefighting include (1) exterior landscaping which makes emergency approach difficult; (2) light construction parking ramps prevent apparatus from reaching buildings; (3) turns which are too narrow for fire apparatus approach; (4) fire hydrant placement too far away.

There is a great need for careful, detailed planning of a structure and its surroundings at the design stage concerning basic fire detection and smoke and fire gas control procedures, alerting and evacuation programs, and careful plans on fighting the fire from the inside.

The National Research Council of Canada has determined that total evacuation is not practical from any building over 30 stories in a reasonable period of time. Even in a 20-story building, it takes up to 20 minutes to evacuate people in emergency drills.

Codes still regulate the service materials and exterior finishes for corridors based on fire tests not applicable to modern materials. The spread of fire can be dramatically reduced by requiring all corridor materials to be noncombustible.

The carpet should meet the new criteria for fire safety established by the National Bureau of Standards using a radiant heat test tunnel.

There is another myth that if a building is sprinklered, combustible materials may be used safely and the corridor length extended beyond 100 feet between exits. Unfortunately, with modern polymers, the smoke load and flame travel rate may be so great and move so rapidly before the sprinklers operate that a corridor quickly can become non-usable.

Regarding school fire drills, school corriders and classrooms, even though noncombustible, have proved to be hazardous in fire experience where basically wood is involved.

Next is the elevator. The message everywhere is "do not use it in case of fire." Elevators by law in many areas return to the ground floor.

The problem of why smoke goes up an elevator shaft should be analyzed by those writing the laws. It has been shown by work from Brown University and the National Bureau of Standards that smoke will move up to 50 feet per minute for the first three minutes of a fire, and then up to 100 feet per minute.

Vertically, that is 10 stories a minute. The smoke can be stopped by closing the flue at the top of the elevator. Again, an understanding of the aerodynamics of heat flow in a building can solve many of the problems.

The vent at the top of an elevator shaft is a major factor in permitting many working fires to quickly involve an entire building.

Design points which deserve consideration include non-fire-stopped shafts, locked exit doors, combustible ductwork, combustible coatings, combustible plumbing materials, etc.

Attempts are being made to control construction and contents with test procedures which often bear little relationship to how they burn in a real fire. Little has been done to control quantity and rate of smoke and gas release of materials. The subject of fire technology is not taught in most architectural and structural engineering schools. Fire spread should be included in the fire reporting.

Many colleges and universities are now developing courses on fire technology. Standards groups are evaluating relevant hazards and tests for them. The American Society of Heating, Refrigerating and Air Conditioning Engineers is developing a new concept of using air under pressure to reduce the real potentials of a high-rise towering inferno. This use of air for smoke and fire control is not yet an exact science, but the record so far is impressive.

There is a "neutral point" usually near the middle of the building where air pressures are static or "neutral." Below this point, fire gases in non-pressurized buildings move into the building. Above the "neutral zone" smoke and fire gases move out.

In July 1972 a number of room burnout fire tests were conducted at the Henry Grady Hotel in Atlanta to determine the effectiveness of stairwell pressurization and the performance of certain materials under fire conditions in "low hazard" occupancies. The details of these fire tests were discussed by Mr. Taylor. The results of these tests are available in booklet form from Norman Koplon, Architectural Engineer for the City of Atlanta.

The fact that pressurization works was proven in an actual fire on March 7, 1974, at the Carlyle Apartment in Lakewood, Ohio. This apartment had corridor pressurization. Everyone evacuated safely and the fire was blackened down 15 minutes after the alarm was sounded.

Unusual was the tightness of the corridor and the almost complete burnout of the suite in which the fire occurred with almost no communication to the corridor.

The data gathered from this fire tends to confirm work done by the Canadian Building Research Council, the National Bureau of Standards and others. It shows: (1) fire on a lower floor below the neutral plane can be spread into a corridor by the airflow; (2) smoke from floors below the neutral plane can be spread to upper floors by entrainment into the supply air system if the system is not balanced to provide a positive supply to all floors under all conditions; (3) fire on upper floors can be contained in the fire room of origin by the airflow from a positively pressurized corridor; (4) smoke on upper floors will be forced outside; (5) weather can have significant effects on the pressures in the building.

From the study of the Carlyle it would appear that: (1) Positive pressurized corridors using a "make-up" air system can contain a fire within a suite if: (a) the system is properly balanced, or (b) the fire occurred in a suite above the neutral plane. (2) With pressurized corridors the following are essential: (a) stairwells should be pressurized more than corridors to keep smoke and fire gases out of stairwells and vents at the top of the elevator shafts should be closed; (b) non-combustible corridor construction, including doors, door frames, door hardware, acoustical ceilings, wall coverings and service and communications conduit and pipe are critical since radiant heat is a factor despite pressurization; (c) corridor exhaust systems should be of a non-combustible material; (d) suite exhaust systems should be non-combustible; (e) all corridor doors should have automatic self-closers; and (f) each fire compartment should have exterior windows or vents.

Positive air supply at approximately 0.10 inches of water pressure kept this fire out of the corridor even though the door had failed. Requirements for 0.15 inches of water pressure appear excessive in condominium-apartment type buildings.

Since that fire, there have been others where corridor pressurization has worked. Pressurization does work, sometimes even without an air system as illustrated by a fire in Dallas, Texas.

The question was raised as to whether or not air conditioning systems in high-rise office buildings take off early fire gases to the point where fires have a hard time developing.

Pressurization is a sound firefighting tool. With it firemen can get to the scene and fight a fire. If life-safety is truly our concern, then smoke detection, early voice alerting and pressurization are the keys to future life-safety from developing fires in fire-rated structures.

Much has been learned about flashover and the need for full-scale room burning. But smoke and toxic fire gases in the early stages outside the immediate fire area are most critical to human life.

Through pressurization the elevators can be protected and used to move people sensibly. We urge your support on the design use of air systems for life-safety and property control in buildings.

MR. MASTERS: Problems which the design engineer faces today are numerous. There is a lack of complete understanding and knowledge of methodology in engineering smoke control systems.

The kind of problem that design professionals are confronted with is illustrated by a statement from the latest NFPA 101 Standard--a life-safety code which many use in design. "Access corridors in buildings seven or more stories in height shall be continuously pressurized to a minimum of .01 inches on any unit door."

Conspicuously absent from this particular statement is any limitation on the maximum pressure that may be developed. If one is designing to a minimum, then there must be some factor put into the design to make certain that that minimum value is always exceeded.

In Massachusetts, as it relates to the amount of air and the amount of pressure that has to be maintained in stairwells, the same .01 number appears in the latest Commonwealth of Massachusetts Code relating to air pressurization, and requires that no less than 60 air changes be provided, regardless of building height or configuration of stairs.

Further, it requires that all air be introduced at the bottom, regardless of building height. With those stipulated code requirements, it may be possible to generate a situation which, although consistent with the code, could be more dangerous than the absence of a pressurization system.

This points to panic legislation written by people who are properly motivated but without the tools to either understand or solve the problem.

The situation exists where people writing the legislation do not have the benefit of proper backup advice and information relative to limitations of equipment, dynamics of the forces created, fan controls, etc.

There is a need for some good basic research. Good work has been done under the auspices of the National Bureau of Standards, through private practitioners, various municipal agencies, state agencies and Canada.

Technology has been developed to a point where, given a smoke control design task and unlimited funds and time, a workable solution could be developed for a particular building which relates to pressurization and smoke removal.

However, society is economically oriented and people are held personally accountable for their actions. The rigors of professional liability preclude the undertaking of a design task for which there is potential danger to life and the acceptance of questionable codes.

No one can actually state for a given building, for a given size and elevation, precisely what amount of air will accomplish the desired result.

If a stairway pressurization has to function under all conditions of usage, it must function and maintain safe pressures when doors are closed and when they are open. It does no good to design a system which maintains safe pressures only when the doors are closed. Similarly, an excessively pressurized stairway will deny access to it, and the solution becomes self-defeating.

An objective should be to develop a simple, reliable system that has none or limited automatic control. Automatic controls are subject to malfunction and should be reduced to an absolute minimum in a life-safety system.

The emphasis of methodology of control in smoke control systems has to be looked at quite differently. One approach to excess pressure relief might be in relieving excess pressure in a stairway by a simple barometric drafting. While this arrangement might violate the fire resistant integrity of the stair enclosure, a fire damper could be added.

A one and one-half hour fireproof, self-closing door in stairways is permitted. When the door is open, there is no fire integrity. New thinking has to be responsive to the design problem in order to relate to relative risks.

New research is designed to get into the range of dynamic systems by fighting fire with the use of air systems. A clear definition of the problem and an indicated solution must be in the design manuals. Engineers need information they can work with and information that is proven and reliable enough to insure workable design. That is what this program is all about.

MR. TAYLOR: Work done at NBS and the Canadian Building and Research Council indicates that six air changes per hour is the maximum that is needed. It may be possible by good design to get down to three or four air changes per hour. Then use of the regular air conditioning system is practical almost everywhere for smoke control.

Francis Fung will next speak on smoke control concepts of different countries.

MR. FUNG: This slide depicts a smoke situation down a 30-foot corridor with both ceiling and walls lined with gypsumboard. The carpet is the only combustible. The four wood cribs to the end of the corridor were the only combustibles being ignited. Due to the heat generated from the burn room and subsequent heat transfer to the acrylic carpet, in only five minutes smoke billows out from the corridor. This burning will continue until the carpet is completely consumed.

In a high-rise building, aided by stacking and buoyancy, smoke billowing out from a short corridor will infiltrate the rest of the building.

The vertical scale indicates the height of the building in feet, and the middle point is the neutral plane. The different intensity of the pressure is indicated by a relative scale, assuming that the room temperature is 70 degrees. A maximum pressure difference of .5 inches may be expected.

The passage of smoke can be devastating in terms of life-taking potential, property damage and its obstruction to firefighting.

In order to evaluate the effectiveness of smoke systems, a trace gas technique experimental methodology was developed. This involves the setting up of a burn room with warm and pressurized air. This pressurized air will simulate smoke from a burn room. Infiltration of SF6 tracer gas carried by the smoke will be sampled quantitatively to obtain a smoke infiltration profile.

The effectiveness of any given smoke control system is compared with the building in normal operations. The Seattle Federal Building has a zoned systematic pressurized system for smoke control. The concept is that the building can be divided into seven zones, and given a fire situation, the fire zone in three floors will be exhausted. Immediately above and below will be pressurized to keep the smoke from moving away and infiltrating the rest of the building.

The stack effect in a stairwell will move smoke which is positive at the bottom and negative on the neutral plane with respect to the floor. The pressures are such in a sheltered interior stairwell that there will be less pressure differences than the maximum predicted. This is a desirable situation. It means in smoke control the building can be designed to counter interior stairwell pressure differences rather than maximum external differences.

In a simulated smoke control mode where the middle zone around the 20th floor is exhausted and the floors above and below are under pressurization, the smoke control mode was able to overwhelm the normal profile and have a pressure profile which will prevent the smoke at the middle zone from moving up and below the fire zone.

The San Diego VA Hospital is an interesting building with four individual wings, connected by corridors to a central core. The elevator shafts are in the central core. Each floor and wing have individual HVAC systems which can be controlled individually.

Experiments were performed with this building, simulating a horizontal smoke control mode. When smoke was simulated in the south wing, pressurization was exhausted and the west, north and east wings were pressurized to keep the smoke from moving away from the south wing. In a pressure measurement, smoke control mode was achieved. When there was smoke control there was no measurable smoke infiltration of the building except in the fire wing itself.

Various smoke control ideas being applied overseas in shopping malls are not included in the experiments from abroad; only those from average type high-rise buildings.

A Canadian experiment recommends that all fire areas be pressurized and that the fire floor be provided with a means of venting to outdoors by smoke shafts or windows. Another suggestion was the pressurization of the central core in a high-rise building. One other smoke control idea might be, in the case of two separate buildings connected by a bridge on each floor, to separate the two buildings to prevent fire from spreading from one wing to the other.

The French emphasis is to supply air from the bottom of the corridor floor and to pick it up from the ceiling of the corridor. It is hoped that stratification exists so that smoke gets to the top and cool air is supplied on the bottom for safe exiting.

A smoke control method which the British are using consists of distributing air supply into the stairwell and thus developing a pressure throughout the stairwell of 58 Newton per meter square. The fire floor is vented to the outside; thus there is a need to exhaust or evacuate the hot combustible airs and smokes from the source.

Incidentally, smoke is not only toxic by itself; it also obstructs firefighting and is also combustible. When a sufficient amount of this combustible is accumulated in any wide-open area, with the right temperature, flashover occurs. It is advisable to exhaust as much of the unburned combustibles from a fire as you can.

It is the recommended practice in firefighting to vent combustible mixtures to avoid a flashover.

To calculate the force on a door of 20 square feet, take 50 times the pressure difference in terms of inch of water. Only a .2 inch pressure maximum can be permitted. In general, in a fire, the pressure attenuates very quickly away from the fire. Generally accepted opinion is that the energy from the system can overcome the pressure of a fire except in the immediate vicinity of a large fire. Away from the fire the system can develop sufficient pressure to control smoke.

Smoke control by proper application of HVAC systems as a life-safety feature in a large modern structure is here today. Many experts around the world strongly recommend it and practice it. However, the various smoke control approaches are lacking systematic and optimization studies and guidelines.

The architect does not know what smoke control concepts are available and which is appropriate for his building for the level of protection needed. The designer does not have the ready tools to transform the concept to HVAC requirements for a specific building.

A systematic and comprehensive study of available concepts is needed. Next, a matrix of design guidelines for proper selection of smoke control concepts for a given building is required. Finally, optimization and design studies have to be performed by application of theoretical analysis, large and small scale experiments and computer studies.

This comprehensive study has to be transformed into a volume containing charts, graphs, tables and formulas--the tools a designer is accustomed to using. External effects such as the wind and temperature differences have to be included. In addition, building characteristics--in terms of geometry, volume and special features--have to be considered.

The manual also should incorporate codes and standards that have been enacted on pressure and flow requirements for a specific smoke control.

This smoke control design manual for engineers is a monumental and costly task, but the art of smoke control needs this manual for the propagation of its cause. Without this comprehensive design tool, the progress of smoke control will continue to move in an aimless manner. In the end, whatever spark or brilliant smoke control ideas that come along will remain in the hands of a selected few without achieving the full benefit of saving lives.

MR. TAYLOR: We do not have all the answers on pressurization systems. We do know, however, that a smoke control system can be designed quite accurately. But until the structure is erected and actually tested, it is difficult to predict exactly how well it will work. This is an area where improvement is needed. Smoke control systems are not expensive. Quite the contrary. If smoke control design is part of the building systems package, the problems and programming of the automatic switching of systems can be accomplished off the basic control equipment.

The problem of wind was one of the design parameters. The wind is no problem until the building loses its windows.

Smoke control systems can be practical and reasonable in cost. Available to you today is a tentative research project report, TRP 206.

No one system is going to solve all the problems. Early warning detection is still needed as well as training of staff. The protective systems already in use should be continued. Smoke control is just one major new tool which will reduce the potential of a fire moving out of the area of origin.

Brooks Semple will next present a discussion of pitfalls of modern design and materials.

MR. SEMPLE: A very common fire start is one with a clean flame, plenty of oxygen and not much smoke. This is the way a fire started in an automatic transmission plant in Livonia, Michigan. This particular fire rewrote the codes for industrial plants.

Livonia, Michigan, had a number of acres under one roof. A residential bedroom is approximately 200 square feet. That gathering of smoke at the ceiling stops at the side walls and has no place to go but down.

The Livonia, Michigan, fire did not get to the stage where the air became contaminated and people had to be evacuated. Personnel safety is not a major problem in one-story plants, no matter how many acres they are.

Those areas where fire protection engineers have been applying their talents are those areas where dollars were protected, not lives.

The first five minutes of a fire are more important than the next five hours.

As stated earlier, the Henry Grady fire helped establish the use of pressurization for smoke control. The Atlanta motel test fire further tested pressurization, but it was mainly a test of inexpensive sprinkler systems for bedrooms.

The furnishings in the Henry Grady were less than normal. There were no draperies nor combustibles on the walls or ceiling--only a carpet pad, one bed, no overstuffed chair and no papers strewn about. This bedroom was furnished more sparsely than your own.

In 3 minutes and 40 seconds, the flame became self-extinguishing because the door was closed. There is no need to furnish hotel rooms with sprinklers. The fires will be self-extinguishing as long as the doors remain closed. The people inside will be self-extinguishing too. This is the new problem we have.

Built-in extinguishing systems have done a tremendous job in holding down insurance premiums because of the reduction of loss and incidents of substantial loss where great masses of property are assembled under a single roof.

When the motel bedroom door was left closed, the fire room was vented in 17 minutes following self-extinguishment. The fire was reignited, and after 18 more minutes the sprinkler opened. At that point the fire was no longer visible because of the heavy smoke.

At the moment of opening the door, there was little fire pressure pushing the smoke out. In another minute the airflow switched around to a natural draft. Because fresh air is flowing into the fire room, it is clean for the first three feet of elevation. Fresh air feeds the fire. It develops the fire so that heat builds up and the sprinkler head opens. The fire would never have left that room of origin and catastrophe would have been averted. Sprinkler systems are still the best way of averting catastrophe. No where in recorded history have 12 or more people been lost in a sprinkler building.

Fusible link manufacturers are given a latitude of 10 degrees Fahrenheit plus or minus five. A fusible link must open between 160 and 170 degrees Fahrenheit <u>in water</u>. However, the "UL Standard 33, Standard For <u>Fusible Links</u>" which is also used for fusible links on sprinkler heads, allows an ordinary range fusible link (from 125 to 170 degrees Fahrenheit) which need not open until 290 degrees Fahrenheit.

On UL's particular time temperature curve, 290 degrees Fahrenheit occurs in six and one half minutes. The fire may push faster and hotter than that.

A therma-couple was mounted on the link in the test bedroom. The ceiling temperature never exceeded 225 degrees Fahrenheit until the door was opened. This is why the 165-degree links do not open. Thus we cannot depend on any heat-sensitive device, as now widely marketed, for life safety in the room of fire origin.

Smoke control depends on smoke detection. Thermal devices are too slow.

Crib burns are familiar to everyone in the fire profession. A crib burn was conducted in Sacramento four years ago. A small five-room frame house was used. The walls were plaster and the wallpaper had peeled off. There was no paint on the wall.

The only combustible part of the house that could have been exposed to any fire internally was the window and door frames and the carpet padding in the living room.

Because the living room was the largest room in the house, it was used for the test. The idea was to test the difference between materials commonly used in a home a generation ago and those used today.

Twelve minutes from ignition was self-extinguishing. If the infant had been on the floor, it would have survived.

Today we are in a plastic era. There has been a tremendous growth in the use of plastic furnishing.

In the fire test of the foam mattress and common plastic covering on the crib, both cribs were identical at 30 seconds into the fire. After that period the identity ceases. Flashover occured at three and one half minutes.

We have a substantial problem and need help.

MR. TAYLOR: A smoke detector, UL labeled, should be properly installed in all residences. Secondly, be certain that the label is not a ULC label. That only identifies conditional certification. Those in a position to do so should urge legislation and code action. Legislation should be enacted to require smoke detectors in all new buildings as well as existing structures.

This new plastic era is here. The wood era is fading.

In a plastic era, the same time limits do not exist. The toxicity is much even in a beginning fire, that unless easy access is available, the fire department should fight the fire. The fire department should also be aware of toxic gas hazards. Even though the fire might seem a clear one, gases cannot be seen and masks should be worn. It is the clearest smoke which is the worst and that occurs in the early stages of fire.

Bill Schmidt of the Veterans Administration will next speak on the design needs of NFPA 90A, the Air Conditioning Code.

MR. SCHMIDT: The NFPA standards are widely used, either directly as in the private sector, or through various Agency requirements in the Government.

Years ago the installation of fire dampers in ducts was the way building fire safety was designed. About three years ago Appendix B was added to the code to permit the systems to be used as smoke control systems.

However, because of the increased awareness of smoke and toxic gas danger, much has been done. Most of the progress has been in the life-safety code.

One section of the code requires that in a building with seven or more stories, the corridor be continuously pressurized to a minimum of .01 inches at every living unit door. This means that the air conditioning and ventilation systems are used.

The 90A code states that the corridor cannot be used as a portion of a supply or return air plenum. This presents a conflict to the designer.

The 101 approach is the right way to go.

Section 9 concerns shopping malls. It requires that a covered mall shall be provided with smoke control in accordance with 12-37.

Perhaps the most important section concerns the use of smoke dampers and fire dampers in partitions. Openings in fire partitions for air ductwork or air movement shall be protected with fire dampers. This requirement need not apply, and this is the exception, for ductwork is part of an engineered smoke control system. Smoke control has almost eliminated the need for fire dampers.

The 90A committee has discussed the use of ductwork, sprinklers and dampers. 101 has taken fire dampers out, which is quite substantial.

The seriousness of smoke control systems is reflected in the life safety code. There is willingness to trade off fire and smoke dampers to obtain a good smoke control system.

ASHRAE has done a great deal. In addition, there is available within the Society reports on buildings which have been built, smoke tested, redesigned and retested.

One of the most important activities in ASHRAE is to get material into print and get it referenced for use by designers. There is also the insurance and professional liability which have to be considered. The consensus method must stand up in court to protect everyone.

The NFPA is endeavoring to get as much as possible into Appendix B. The building air conditioning systems that have been designed and installed for normal cooling will be used. This has been found to be more than adequate in most cases to do the job.

MR. TAYLOR: Many people still question how much of the above is an experiment and how much is proven. In Atlanta, every high-rise erected during the past four years has had different types of pressurization systems designed into it.

There have been no fires which have gone beyond the incident stage in these pressurized buildings in the past three years.

In some of the local governments there has been cost-cutting which has forced fire departments and building departments into a position of insufficient manpower to properly design building fire safety and conduct fire prevention inspections along with their fire extinguishment duties.

It will take a national effort to educate local officials and the American public that more critical than the firefighting may be the building review initially and the need for continued inspections by both building and fire departments.

The irony of fire suppression is that by putting out the fires and having a low loss record, the city councils then cut into the fire departments' budget and manpower. This portends a tragedy.

The air conditioning systems can be used to control smoke in the early stages of a fire. The codes should be changed to permit the air systems to remain on until they are automatically reconfigured to a smoke control mode. As long as fresh air is circulating, the problems of panic in a fire are dramatically reduced.

The Squibb Building in New York was a case in point. The air systems were turned off and 1,600 people on upper floors panicked. Windows were smashed. When the air systems were turned back on, the level of panic in the area dramatically lessened.

Currently designers do not have a coherent pressurization design criteria to work with, as is available in almost all other engineering disciplines. In addition, designs are based on individual philosophy and limited data. There is a need to go in after construction and retrotest to be certain that what was done was correct. Design guidelines need to be printed. Finally, there is the liability which exists from unproven techniques.

The actual design technology available is extensive. Many of the techniques have been proved and tested. However, the technology has not been catalogued for what is needed; yet an effective design system is

dependent upon the structure that it is going into and the HVAC system. Critical to this is the HVC system and structural leakage.

What can be done in existing buildings where retrofit cannot be accomplished? Pressurized elevator shafts may be one way to stop stack effect in the building and create a staging area for firemen. A further concept is to then put a fan on the car itself to pressurize the lobby area.

I challenge the concept of taking the elevator car out of service during the first three to five minutes after an alarm has sounded. There is no record of any individual having been injured or dying in an elevator in a high-rise building in recent years, other than after the HVAC system is turned off.

Smoke control should be tied into the air systems. The system must be economical and effective.

There is a 10-story hospital which is now divided into 30 different smoke zones. People in all but three or four of the zones never even know when a fire call comes in. This is developing real life-safety.

Coherent design guidelines can be developed. Limited initial effort is underway at the National Bureau of Standards, but it must be expanded.

All existing criteria should be put together in one consensus and the existing experimental work extended to all significant structural designs. This means expanding the National Bureau of Standards' work to provide design guidelines for all types of structures. This design guide will provide the necessary tools needed by engineers, architects and building and fire officials to judge the validity of the system and to smoke-test it.

ASHRAE will endeavor to provide a coherent design basis in the form of a manual, as a part of the ASHRAE Handbook. The manual will provide an effective and rapid dissemination of design technology.

QUESTION: Where are the sources of information now for this type of design? Does ASHRAE have a good source list for designing of smoke control systems?

MR. TAYLOR: ASHRAE has a supply of materials available on this subject. NBS also has material available on sources. Certain Canadian papers are available. However, the data available today is fragmentary, and it is difficult for designers and architects to pull it out.

MR. FUNG: The data available at this point is basically of a research nature. It is not design information in a usable form. There is still much work to be done to pool the resources and write the design formulas, charts and tables.

Research is the first step toward technology. But there is a great deal that has to be done to transform this technology into design tools.

MR. SCHMIDT: The February 1976 issue of the ASHRAE Journal was a special fire safety issue. The most extensive reference that was available was included in the articles.

QUESTION: Has the engineering problem of laboratory buildings where there are multiple hoods with a lot of ventilation for toxic materials been addressed?

MR. FUNG: There are computer programs which will simulate this type of building. There are experiments, comparative programs, small and large scale studies which can simulate a building with these specific problems. It is costly to run this program and the tools are not available to everyone. Still needed are charts and formulas to check against each building.

MR. SCHMIDT: Actually in laboratory buildings with hoods there is a built-in ready exhaust system. Let the hoods run. A hood fume will probably determine the amount of airflow. The smoke control system must have both supply and exhaust.

MR. FOTHERGILL: The NIH Clinical Center will be tested in June and should give some experimental data in what is necessary when materials of this sort use hoods to maintain evacuation of toxic products.

QUESTION: How can copies of experimental data be obtained?

MR. FOTHERGILL: The best source to contact is Francis Fung of the Center for Fire Research at the National Bureau of Standards.

MR. FUNG: ASHRAE and NRC of Canada are the other two sources for additional information.

QUESTION: What effect will energy conservation have on smoke control, such as opening windows instead of having fixed windows. Does this affect the firefighting operation?

MR. SCHMIDT: The window problem actually in this GSA building is one type of corridor. Most buildings are block-buster type with a perimeter of rooms and an interior core.

QUESTION: I was referring to the effect it would have on the smoke control system.

MR. SCHMIDT: The firefighters know whether or not they are above or below the neutral plane. An open window at the wrong place could either save or kill.

The entire concept of energy conservation, the load shedding of fans at any particular time of day, adds an additional complication. Fortunately, most of the systems for buildings are now being designed for occupancy.

The computerized control system is becoming more popular. All the systems are brought in electronically with computer surveillance.

In new buildings the cost factor may be inconsequential. So, in some ways the energy conservation has helped.

VOICE: Do you perceive a trend to go to an HVAC smoke control option or elimination of the damper? Or do you see some combination of the two?

MR. SCHMIDT: There will be a combination of the two because a physical barrier is needed.

MR. FOTHERGILL: Pressurization is only one technuqie. Compartmentalization is a very significant and economical technique. It is closely related to both fire protection and energy conservation. Even a small compartmentalization scheme helps in the smoke control area.

QUESTION: There are many kinds of combustibles in areas of these high-rise buildings--in the computer room, storage area--where the fire might get out of control. During the initial period of the fire, there will be additional protection. However, in a 2000-degree fire, there are not adequate facilities to overcome pressurization.

MR. SEMPLE: Smoke detectors are extremely important to any smoke control system. The primary thing to remember is to call the fire department at the first smoke detector signal.

Smoke control systems are not designed to replace fire ratings of walls. They are designed to help the fire professionals perform the first two items that they must perform. The fireman's first function is to ensure that everyone has been evacuated from the involved area.

His second function is to find the fire. With the smoke control systems, the fire is being fed.

QUESTION: What about pressurization systems for sprinkler protection?

MR. SEMPLE: Absolutely not. It is not meant as a substitute. Smoke control systems are intended to be the first line of life-safety protection because they are smoke actuated--thermally actuated. Extinguishing devices are not fast enough.

MR. FUNG: Smoke control is only one of the whole schemes of fire and smoke safety measures. However, it is significant since it concentrates on life-safety more so than property protection. It is the toxic products that kill, obstruct firefighting and accumulate combustibles in areas away from the fire.

Smoke control can eliminate the toxic smoke away from the origin of fire. It can remove some of the combustibles that cause flashover and can increase visibility by removing smoke.

There are concerns about pressure differences due to fire. One basic phenomenon of air pressure in free expansion is that it attenuates very rapidly. In fact, it attenuates as the inverse of the distance.

BIBLIOGRAPHIC DATA SHEET	1. Report No. 09A78000013	2.	3. Recipient's Accession No.
4. Title and Subtitle SEMINAR ON SMOKE CONTROL AS A PART OF BUILDING FIRE PROTECTION, MAY 3, 1977			5. Report Date January 24, 1978
			6.
7. Author(s) R Klinker, R Taylor, F Fung, B Semple, W Schmidt, R Masters, W Hanbury			8. Performing Organization Rept. No. NFPCA
9. Performing Organization Name and Address FEDERAL FACILITIES DESIGN STANDARDS TASK GROUP NATIONAL FIRE PREVENTION AND CONTROL ADMINISTRATION DEPARTMENT OF COMMERCE WASH DC 20230			10. Project/Task/Work Unit No. FFDSTG-2
			11. Contract/Grant No. --
12. Sponsoring Organization Name and Address Jointly sponsored by the Task Committee 5.6 on Fire and Smoke Control, American Society for Heating, Refrigeration, and Airconditioning Engineers, Inc. (ASHRAE).			13. Type of Report & Period Covered SUMMARY MINUTES
			14.

15. Supplementary Notes
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16. Abstracts

The meeting was held to discuss the background, development, and status of smoke movement and control technology as it pertains to building fire protection. This was a jointly sponsored meeting with the Fire and Smoke Control Task Committee of ASHRAE.

In recent years, considerable effort has been devoted to this subject. Other countries, as well as the US, have recognized the potential value of using smoke control systems to assist in the safe evacuation of buildings while minimizing the adverse effects of fires or other emergency situations endangering personnel and property. Also, some design choices that have been implemented in new buildings have been costly, but accomplished little.

17. Key Words and Document Analysis. 17a. Descriptors

Air conditioning
Buildings
Design
Fire protection
Polyvinyl chloride
Pressurization
Safety Engineering
Stairways
Toxicity
Ventilation

17b. Identifiers/Open-Ended Terms

Combustion products
Corridors
High-rise buildings
Pressurized corridors
Pressurized stairways
Smoke control
Smoke movement
Stack effect
Toxic gases

17c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Release Unlimited.	UNCLASSIFIED	11
	20. Security Class (This Page) UNCLASSIFIED	22. Price

U.S. DEPARTMENT OF COMMERCE
National Fire Prevention and Control Administration
Washington, D.C. 20230

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